CLAIMS

We claim:

1. An apparatus comprising:

a pendulum assembly, including:

a coarse pendulum, and

a fine pendulum coupled to said coarse pendulum;

a laser beam source assembly mounted on said pendulum assembly, wherein said laser beam assembly provides a first laser beam.

2. The apparatus of claim 1, further including:

a first motor coupled to said pendulum assembly; and

a first reflective element coupled to said first motor to rotate in response to a rotational movement of said first motor, wherein said laser beam source assembly is aligned to provide said first laser beam to said first reflective element.

3. The apparatus of claim 2, further including:

a second motor mounted on said pendulum assembly; and

a second reflective element coupled to said second motor to rotate in response to a rotational movement of said second motor, wherein said laser beam source assembly is aligned to provide a second laser beam to said second reflective element.

4. The apparatus of claim 3, wherein said first laser beam is perpendicular to said second laser beam.

5. The apparatus of claim 3, wherein said first motor and said second motor are mounted on said coarse pendulum.

6. The apparatus of claim 5, wherein said first reflective surface and said second reflective surface are mounted on said coarse pendulum.

7. The apparatus of claim 6, wherein said laser beam source assembly is mounted on said fine pendulum.

8. The apparatus of claim 7, wherein said first reflective element is a penta-prism and said second reflective element is a penta-prism.

9. A laser alignment device comprising:

a pendulum assembly;

a first motor mounted on said pendulum assembly;

a second motor mounted on said pendulum assembly;

a first reflective element coupled to said first motor to rotate in response to a rotational movement of said first motor;

a second reflective element coupled to said second motor to rotate in response to a rotational movement of said second motor; and

a laser beam source assembly mounted on said pendulum assembly, wherein said laser beam source assembly is aligned to provide a first laser beam to said first reflective element and a second laser beam to said second reflective element.

10. The laser alignment device of claim 9, wherein said pendulum assembly includes:

a coarse pendulum; and

a fine pendulum mounted to said coarse pendulum.

11. The laser alignment device of claim 10, wherein said first motor and said second motor are mounted on said coarse pendulum.

12. The laser alignment device of claim 11, wherein said first reflective surface and said second reflective surface are mounted on said coarse pendulum.

13. The laser alignment device of claim 10, wherein said laser beam source assembly is mounted on said fine pendulum.

14. The laser alignment device of claim 9, wherein said first reflective element is a penta-prism and said second reflective element is a penta-prism.

15. The laser alignment device of claim 9, wherein said laser beam source assembly includes:

a mounting block containing a first opening and a second opening;

a first mounting joint secured in said first opening, wherein said first mounting joint includes a first front section located in said first opening and said first front section has a spherical surface; and

a second mounting joint secured in said second opening, wherein said second mounting joint includes a second front section located in said second opening and said second front section has a spherical surface.

16. The laser alignment device of claim 15, wherein said laser beam source assembly includes:

a first laser diode mounted in said first mounting joint; and

a second laser diode mounted in said second mounting joint.

17. The laser alignment device of claim 16, wherein said laser beam source assembly includes:

a first collimating lens mounted to receive a beam from said first laser diode; and

a second collimating lens mounted to receive a beam from said second laser diode.

18. The laser alignment device of claim 9, wherein said laser beam source assembly includes:

a mounting block, including a channel;

a laser diode mounted in said channel;

a reflective element mounted in said channel; and

a collimating lens mounted in said channel between said laser diode and said reflective element,

wherein said reflective element includes:

a first reflective surface aligned at an angle to a collimated laser beam originating from said laser diode and passing through said collimating lens, and

a second reflective surface aligned at an angle to a collimated laser beam originating from said laser diode and passing through said collimating lens.

19. The laser alignment device of claim 18, wherein said reflective element is a bi-mirror.

20. The laser alignment device of claim 9, further including:

a housing;

a mounting bracket pivotably mounted within said housing, wherein said mounting bracket supports said pendulum assembly;

a yaw arm extending from said mounting bracket; and

a yaw motor having a shaft, wherein a portion of said yaw arm rests against said shaft.

21. The laser alignment device of claim 20, wherein said mounting bracket pivots in response to a rotation of said shaft.

22. The laser alignment device of claim 9, further including:

a control subsystem coupled to said first motor, wherein said control subsystem includes a processor readable storage medium having processor readable code embodied on said processor readable storage medium, said processor readable code for programming a processor to perform a method, said method comprising the steps of:

(a) retrieving a positioning input for said first motor;

(b) determining a first motor control signal frequency, in response to said positioning input;

(c) determining a first motor control signal pulse width, in response to said positioning input; and

(d) providing a first motor control signal to said first motor, wherein said first motor control signal has said first motor control signal frequency and said first motor control signal pulse width.

23. The laser alignment device of claim 22, wherein said positioning input corresponds to a period of time an input is selected.

24 The laser alignment device of claim 23, wherein said first motor control signal frequency has the following relationship to said period of time:

$$\text{Frequency} = \text{Minimum}([K_0 * 10^T], [f_{max}])$$

wherein:

Frequency is said first motor control signal frequency,

$K_0 = 10^{\text{Log}(fmax) - IC1}$

f_{max} is a maximum motor control signal frequency,

IC_1 is a time at which f_{max} occurs, and

T is said period of time.

25. The laser alignment device of claim 23, wherein said first motor control signal pulse width has the following relationship to said period of time:

If T is less than or equal to IC_1, then $PW = PW_{ideal}$

If T is greater than IC_1, then $PW = \text{Minimum}([\text{Slope} * (T\text{-}IC_1) + PW_{ideal}], [PW_{max}])$

wherein:

PW_{ideal} is an ideal pulse width,

IC_1 is a time at which a maximum motor control signal frequency occurs,

T is said period of time,

PW is said first motor control signal pulse width,

$\text{Slope} = (PW_{max} - PW_{ideal})/(IC_2 - IC_1)$

PW_{max} is a maximum motor control signal pulse width, and

IC_2 is a time at which PW_{max} occurs.

26. The laser alignment device of claim 22, wherein said method further includes the step of:

(e) calibrating said first motor.

27. The laser alignment device of claim 26, wherein said step (e) includes the steps of:

(i) applying a calibration motor control signal to said first motor, wherein said calibration motor control signal has a calibration pulse width and a calibration frequency;

(ii) counting a number of pulses required to rotate through each element in a set of elements on an encoder coupled to said first motor;

(iii) determining an average number of pulses per encoder element for said first motor; and

(iv) determining an ideal pulse width, based on said average number of pulses per encoder element.

28. The laser alignment device of claim 22, wherein said control subsystem is coupled to said second motor and said method further includes the steps of:

(f) retrieving a second positioning input for said second motor;

(g) determining a second motor control signal frequency, in response to said second positioning input;

(h) determining a second motor control signal pulse width, in response to said second positioning input; and

(i) providing a second motor control signal to said second motor, wherein said second motor control signal has said second motor control signal frequency and said second motor control signal pulse width.

29. The laser alignment device of claim 9, wherein said first laser beam is perpendicular to said second laser beam.

30. The laser alignment device of claim 9, further including:

a clutch/release mechanism coupled to said first motor.

31. The laser alignment device of claim 30, wherein said clutch/release mechanism includes:

a friction pad;

a weight coupled to said friction pad;

a pivot assembly coupling said friction pad to said weight; and

a spring connected between a shaft of said first motor and said pivot assembly.

32. A laser alignment device comprising:

a housing;

a pendulum assembly;

a first motor mounted on said pendulum assembly,

a second motor mounted on said pendulum assembly;

a first reflective element coupled to said first motor to rotate in response to a rotational movement of said first motor;

a second reflective element coupled to said second motor to rotate in response to a rotational movement of said second motor; and

a mounting bracket pivotably mounted within said housing, wherein said mounting bracket supports said pendulum assembly;

a yaw arm extending from said mounting bracket; and

a yaw motor having a shaft, wherein a portion of said yaw arm rests against said shaft.

33. The laser alignment device of claim 32, wherein said mounting bracket pivots in response to a rotation of said shaft.

34. The laser alignment device of claim 33, wherein said pendulum assembly includes:

a coarse pendulum; and

a fine pendulum mounted to said coarse pendulum.

35. The laser alignment device of claim 34, wherein:

said first motor and said second motor are mounted on said coarse pendulum, and

said first reflective surface and said second reflective surface are mounted on said coarse pendulum.

36. The laser alignment device of claim 35, including a laser beam source assembly mounted on said fine pendulum.

37. A laser alignment device comprising:

a pendulum assembly, including:

a coarse pendulum, and

a fine pendulum mounted to said coarse pendulum;

a first motor mounted on said coarse pendulum;

a second motor mounted on said course pendulum;

a first reflective element mounted on said coarse pendulum and coupled to said first motor to rotate in response to a rotational movement of said first motor;

a second reflective element mounted to said coarse pendulum and coupled to said second motor to rotate in response to a rotational movement of said second motor; and

a laser beam source assembly mounted on said fine pendulum, wherein said laser beam source assembly is aligned to provide a first laser beam to said first reflective element and a second laser beam to said second reflective element, wherein said laser beam source assembly includes:

a mounting block containing a first opening and a second opening,

a first mounting joint secured in said first opening, wherein said first mounting joint includes a first front section located in said first opening and said first front section has a spherical surface,

a second mounting joint secured in said second opening, wherein said second mounting joint includes a second front section located in said second opening and said second front section has a spherical surface,

a first laser diode mounted in said first mounting joint, and

a second laser diode mounted in said second mounting joint.

38. The laser alignment device of claim 37, further including:

a control subsystem coupled to said first motor and said second motor, wherein said control subsystem includes a processor readable storage medium having processor readable code embodied on said processor readable storage medium, said processor readable code for

programming a processor to perform a method, said method comprising the steps of:

(a) retrieving a first positioning input for said first motor;

(b) determining a first motor control signal frequency, in response to said first positioning input;

(c) determining a first motor control signal pulse width, in response to said first positioning input;

(d) providing a first motor control signal to said first motor, wherein said first motor control signal has said first motor control signal frequency and said first motor control signal pulse width;

(e) retrieving a second positioning input for said second motor;

(f) determining a second motor control signal frequency, in response to said second positioning input;

(g) determining a second motor control signal pulse width, in response to said second positioning input; and

(h) providing a second motor control signal to said second motor, wherein said second motor control signal has said second motor control signal frequency and said second motor control signal pulse width.

39. An apparatus comprising:

a housing;

a first rigid member mounted to said housing;

a second rigid member mounted to said housing;

a coarse pendulum mounted within said housing and having a first base, wherein said first base passes between said first rigid member and said second rigid member;

a fine pendulum mounted on said coarse pendulum and having a second base, wherein said second base passes between said first rigid member and said second rigid member;

a first set of magnets mounted on said first rigid member; and

a second set of magnets mounted on said second rigid member.

40. The apparatus of claim 39, wherein said first base is made of a conductive material and said second base is made of a conductive material.

41. The apparatus of claim 39, further including:

a first motor mounted on said coarse pendulum;

a second motor mounted on said course pendulum;

a first reflective element mounted on said coarse pendulum and coupled to said first motor to rotate in response to a rotational movement of said first motor;

a second reflective element mounted to said coarse pendulum and coupled to said second motor to rotate in response to a rotational movement of said second motor; and

a laser beam source assembly mounted on said fine pendulum, wherein said laser beam source assembly is aligned to provide a first laser beam to said first reflective element and a second laser beam to said second reflective element.

42. The apparatus of claim 39, wherein said coarse pendulum includes a pair of arms terminating in said first base and said fine pendulum includes a pair of arms terminating in said second base.

43. The apparatus of claim 42, wherein said pair of arms for said fine pendulum swing within said pair of arms for said coarse pendulum.

44. The apparatus of claim 39, further including:

a mounting bracket pivotably mounted within said housing, wherein said mounting bracket supports said coarse pendulum;

a yaw arm extending from said mounting bracket; and

a yaw motor having a shaft, wherein a portion of said yaw arm rests against said shaft, and wherein said mounting bracket pivots in response to a rotation of said shaft.

45. An apparatus comprising:

a housing;

a pendulum assembly;

a support member rigidly mounted to said housing;

a mounting bracket mounted to said support member to pivot about a pivot point, wherein said mounting bracket supports said pendulum assembly;

an arm extending from said mounting bracket; and

a motor having a shaft, wherein said shaft is in contact with a portion of said arm, and wherein said mounting bracket pivots in response to a rotation of said shaft.

46. The apparatus of claim 45, further including:

a first motor mounted on said pendulum assembly;

a second motor mounted on said pendulum assembly;

a first reflective element coupled to said first motor to rotate in response to a rotational movement of said first motor;

a second reflective element coupled to said second motor to rotate in response to a rotational movement of said second motor; and

a laser beam source assembly mounted on said pendulum assembly, wherein said laser beam source assembly is aligned to provide a first laser beam to said first reflective element and a second laser beam to said second reflective element.

47. The apparatus of claim 45, further including:

a control subsystem coupled to said yaw motor, wherein said control subsystem includes a processor readable storage medium having processor

readable code embodied on said processor readable storage medium, said processor readable code for programming a processor to perform a method, said method comprising the steps of:

(a) retrieving a positioning input for said yaw motor;

(b) determining a motor control signal, in response to said positioning input; and

(c) providing said motor control signal to said yaw motor.

48. A laser beam source assembly comprising:

a mounting block containing a first opening and a second opening;

a first mounting joint secured in said first opening, wherein said first mounting joint includes a first front section located in said first opening and said first front section has a spherical surface; and

a second mounting joint secured in said second opening, wherein said second mounting joint includes a second front section located in said second opening and said second front section has a spherical surface.

49. The laser beam source assembly of claim 48, wherein said laser beam source assembly includes:

a first laser diode mounted in said first mounting joint; and

a second laser diode mounted in said second mounting joint.

50. The laser beam source assembly of claim 49, wherein said laser beam source assembly includes:

a first collimating lens mounted to receive a beam from said first laser diode; and

a second collimating lens mounted to receive a beam from said second laser diode.

51. A mounting joint comprising:

a face;

a section extending from said face and having a rounded surface extending away from said face; and

a cavity within said section for holding a laser diode.

52. The mounting joint of claim 51, wherein said rounded surface is a spherical surface.

53. A method for positioning a motor, said method comprising the steps of:

(a) retrieving a positioning input;

(b) determining a motor control signal frequency, in response to said positioning input;

(c) determining a motor control signal pulse width, in response to said positioning input; and

(d) providing a motor control signal to said motor, wherein said motor control signal has said motor control signal frequency and said motor control signal pulse width.

54. The method of claim 53, wherein said positioning input corresponds to a period of time an input is selected.

55. The method of claim 54, wherein said motor control signal frequency has the following relationship to said period of time:

$$\text{Frequency} = \text{Minimum}([K_0 * 10^T], [f_{max}])$$

wherein:

Frequency is said motor control signal frequency,

$K_0 = 10^{\text{Log(fmax) - IC1}}$

f_{max} is a maximum motor control signal frequency,

IC_1 is a time at which fmax occurs, and

T is said period of time.

56. The method of claim 54, wherein said motor control signal pulse width has the following relationship to said period of time:

If T is less than or equal to IC_1, then $PW = PW_{ideal}$

If T is greater than IC_1, then $PW = Minimum([Slope * (T-IC_1) + PW_{ideal}], [PW_{max}])$

wherein:

PW_{ideal} is an ideal pulse width,

T is said period of time,

PW is said motor control signal pulse width,

$Slope = (PW_{max} - PW_{ideal})/(IC_2 - IC_1)$,

IC_1 is a time at which a maximum motor control signal frequency occurs,

PW_{max} is a maximum motor control signal pulse width, and

IC_2 is a time at which PW_{max} occurs.

57. The method of claim 53, further including the step of:

(e) calibrating said motor.

58. The method of claim 57, wherein said step (e) includes the steps of:

(i) applying a calibration motor control signal to said motor, wherein said calibration motor control signal has a calibration pulse width and a calibration frequency;

(ii) counting a number of pulses required to rotate through each element in a set of elements on an encoder coupled to said motor;

(iii) determining an average number of pulses per encoder element;

(iv) determining an ideal pulse width, based on said average number of pulses per encoder element.

59. A processor readable storage medium having processor readable code embodied on said processor readable storage medium, said processor readable code for programming a processor to perform a method, said method comprising the steps of:

(a) retrieving a positioning input;

(b) determining a motor control signal frequency, in response to said positioning input;

(c) determining a motor control signal pulse width, in response to said positioning input; and

(d) providing a motor control signal to said motor, wherein said motor control signal has said motor control signal frequency and said motor control signal pulse width.

60. The processor readable storage medium of claim 59, wherein said positioning input corresponds to a period of time an input is selected.

61. The processor readable storage medium of claim 60, wherein said motor control signal frequency has the following relationship to said period of time:

$$\text{Frequency} = \text{Minimum}([K_0 * 10^T], [f_{max}])$$

wherein:

Frequency is said motor control signal frequency,

$K_0 = 10^{Log(fmax) - IC1}$

f_{max} is a maximum motor control signal frequency,

IC_1 is a time at which fmax occurs, and

T is said period of time.

62. The processor readable storage medium of claim 60, wherein said motor control signal pulse width has the following relationship to said period of time:

If T is less than or equal to IC_1, then $PW = PW_{ideal}$

If T is greater than IC_1, then $PW = \text{Minimum}([\text{Slope} * (T\text{-}IC_1) + PW_{ideal}], [PW_{max}])$

wherein:

PW_{ideal} is an ideal pulse width,

T is said period of time,

PW is said motor control signal pulse width,

$\text{Slope} = (PW_{max} - PW_{ideal})/(IC_2 - IC_1)$,

IC_1 is a time at which a maximum motor control signal frequency occurs,

PW_{max} is a maximum motor control signal pulse width, and

IC_2 is a time at which PW_{max} occurs.

63. The processor readable storage medium of claim 59, further including the step of:

(e) calibrating said motor.

64. The processor readable storage medium of claim 63, wherein said step (e) includes the steps of:

(i) applying a calibration motor control signal to said motor, wherein said calibration motor control signal has a calibration pulse width and a calibration frequency;

(ii) counting a number of pulses required to rotate through each element in a set of elements on an encoder coupled to said motor;

(iii) determining an average number of pulses per encoder element;

(iv) determining an ideal pulse width, based on said average number of pulses per encoder element.